V. OTHER MATTERS

A. Amplitude Modulated Radiofrequency Carriers

In its Notice, the Commission notes that NCRP prescribes a more stringent exposure limit for radio carriers which are amplitude modulated than for those which have a constant envelope modulation. Specifically, the NCRP limit for amplitude modulated radio signals is essentially the same as that prescribed by ANSI for the uncontrolled environment, but it applies to all people, whether they are in the workplace/controlled environment or the general public/uncontrolled environment. Comments are sought on this matter.

Motorola believes that the NCRP Standard is credible, and as such can not be dismissed. We also note that ANSI, in its work which led to the 1992 Standard, studied this matter and elected to not prescribe limits specifically for amplitude modulated signals.

Although we endorse and use the NCRP Standard in this matter, we believe that the Commission is warranted, at least for the time being, in accepting and adopting the decision of ANSI to refrain from prescribing a special limit for amplitude modulation. At this time, there is an insufficient data base upon which to scientifically regulate amplitude modulated radio signals.

It is, nevertheless, prudent to recognize that the NCRP did, in fact, see fit to adopt special provisions for this type of modulation. Therefore, the Commission should monitor any relevant biological research on this type of modulation, and take appropriate regulatory action at any time in the future when it may be warranted.

B. Effective Date/Grandfathering

There is a significant amount of Land Mobile equipment in use today; thus, the matter of timeframe with regard to implementation of new Commission Rules is of substantial interest. This is also true with regard to equipment which may be put into use after the Commission's Rules become effective.

First, with regard to existing equipment, Motorola has made numerous measurements of installations and equipment over the last number of years to ascertain compliance with the NCRP Standard and the 1992 ANSI Standard. Much of this information has already been made available to the Commission, either in earlier proceedings or through published, peer reviewed papers. Also, we have for some time provided information in our instruction manuals to educate our customers on those actions which should be taken in order to comply with the relevant safety standards. On the basis of these actions, it is our belief that substantially all of our Land Mobile installations and equipment in use today is already compliant with the 1992 ANSI Standard. It is therefore unnecessary for the Commission to take any specific action with regard to existing Land Mobile installations used in Parts 22, 90, 94, and other related Parts.

Installations and equipment which are put into service after the Commission's Order in this proceeding are likewise expected to be in compliance with new Rules. Thus, the effective date of the Commission's Rules is not generally a critical matter. With regard specifically to portable radio units, however, it is likely that in some cases it may be necessary to measure SAR to establish compliance with the Rules. As discussed by the Telecommunications Industries Association in its filing, it will be necessary to develop standards for measurement procedures and test site facilities, and in some cases to construct test facilities before commencing measurements of SAR. Thus, TIA indicates, the effective date of a Commission Order must be based upon these necessary steps. Motorola generally concurs with the TIA Comments on this matter.

C. <u>The Process and Information to be Used in Establishing Compliance</u>

The Commission seeks comment on the procedure to be used in establishing compliance with the SAR provisions of its proposed Rules, as well as on the amount of detail which should be submitted in conjunction with license applications.

With regard to establishing SAR compliance, we recommend that this process be accomplished as part of radio type acceptance, inasmuch as this is simply another parameter which the manufacturer must measure as part of its design and development cycle, and is in essence simply another characteristic of the radio. We further recommend that the Commission require only that the type acceptance applicant indicate affirmatively that the SAR was measured in accordance with approved procedures, and that it, in fact, met the Commission's requirement. We do not believe it necessary or appropriate to submit detailed data relative to this measurement. The Commission could of course, at any time, request on a spot check basis the relevant information which supports the applicants affirmative statement.

Likewise, for license applications, we believe that it should normally be sufficient to provide an indication by, for example, checking an appropriate box on the application form that the installation has been determined to meet the Commission's Rules. As stated elsewhere, we expect that substantially all Land Mobile installations and equipment, because of the use of relatively low power, in-place work practices, and user instruction manual information, will readily meet the Commission's requirements.

D. Spacing Requirements for Land Mobile Installations

In Appendix B of its Notice, the Commission provided estimated separation distances from a Land Mobile antenna installation to assure compliance with the 1992 ANSI Standard. These distances were based on a worst-case analysis, various power levels, and only for exposure in the downward direction (below) the antenna. The estimated distances ranged from 6 to 20 meters.

Motorola has performed similar analysis and, on the basis of its work, believes that the Commission distances are somewhat overstated. A summary of this analysis is presented in the following paragraphs.

Appendix A contains our analysis of the case provided by the Commission. Base station powers of up to 300 watts are used in this analysis, which represents the highest power available for use by Land Mobile users in the 150 MHz band. As shown in this appendix, the substantial signal discrimination provided by Land Mobile antennas in the downward direction results in a maximum necessary separation distance of less than 20 cm, a distance much smaller than that shown by the Commission. It should also be noted that our analysis was determined on the basis of the uncontrolled environment. The required separation distance would be even smaller for the controlled environment.

The signal from a Land Mobile antenna is, of course, designed to radiate outward in a horizontal direction to provide the most effective coverage. Our analysis contained in Appendix B develops the required spacing for that case. The worst case spacing based on the uncontrolled environment is 6.04 meters, which clearly indicates that a Land Mobile signal will not exceed the ANSI Standard at, for example, a near-by building. However, as discussed elsewhere in this filing, the criteria for the controlled environment is more properly applied to Land Mobile base station installations. The worst case requisite separation distance in this case is only 1.98 meters.

Finally, in Appendix C an analysis is shown for a 3500 watt ERP base station such as might be used in the 900 MHz band for paging. The required horizontal separation distance in this case is as high as 3.58 meters for yagi antennas. However, a more typical omnidirectional antenna would require a worst case spacing of only 0.676 meters.

As can clearly be seen from these analyses, the separation requirements from a Land Mobile base station antenna to meet the ANSI Standard are indeed modest.

E. Exposure of the Users of Cellular Phones

In Appendix E is presented the experimental methodology used by Motorola to evaluate the SAR from its portable cellular phone products along with the results collected over a period of almost 10 years,

The method uses a phantom or substitute human, which is a control model, i.e., it attempts to simulate the tightest coupling conditions in normal use between the cellular phone and the human head. A variety of positions of the phone vs. the head have been tested. The following results are highlighted:

1. The exposure of the users of cellular phones, as illustrated in Appendix E, is below the ANSI C95-1992 peak SAR limit for the uncontrolled environment.

2. The radiating structure of cellular phones consists of both the antenna and the radio case containing the electronic circuitry. The RF currents on the antenna and within the radio case both cause exposure of the user of cellular phones. The intensity of these currents and their distance from the human body are the main parameters determining the instantaneous value of peak SAR in the exposure from portable cellular phones.

3. If the point of peak SAR is not located by the antenna current maximum then it is detected near the metal parts within the phone radio case, which are close to the face of the user.

4. In normal conditions of use, as recommended by the product instruction manual, the peak SAR values are found not in the brain, but in the area of the face close to the ear.

5. Accurate and repeatable SAR measurements require very specialized equipment and personnel.

6. SAR measurements can be used to effectively control the exposure of the users of portable communication devices.

APPENDIX A

SUMMARY

In summary, the distances required to meet the ANSI/IEEE standard at high band in the land mobile industry are much smaller than computed in the NPRM. This is because the main beam of the antenna does not radiate directly down toward the ground and the transmitter power permitted the land mobile industry is much smaller than used in that previous computation.

INTRODUCTION

In Appendix B of the subject NPRM, a worst case analysis of radiation from a dipole is presented, where it's main beam is pointed straight down to the ground. The Appendix shows the minimum height necessary for the fields to meet the Maximum Permitted Exposure (MPE) of the ANSI/IEEE C95.1-1992 standard in the uncontrolled environment. The frequency is anywhere between 100 and 300 MHz, and the results are presented as a function of power into the dipole.

In this Appendix, we will make that computation for the general case of an antenna used as a land mobile base antenna for high band.

ANALYSIS OF DIPOLE FIELDS STRAIGHT DOWN

The land mobile and cellular antennas are vertically polarized, and the general case is when the base station antenna is mounted on a tower or building. The main beam of the antenna is pointing toward the horizon with a gain of 2.15 dBi as shown in Figure A-1 for the omnidirectional dipole antenna. The directivity in the antenna is utilized to point the energy in the direction of the users, namely horizontal, and as little energy as is reasonably possible is radiated downward.

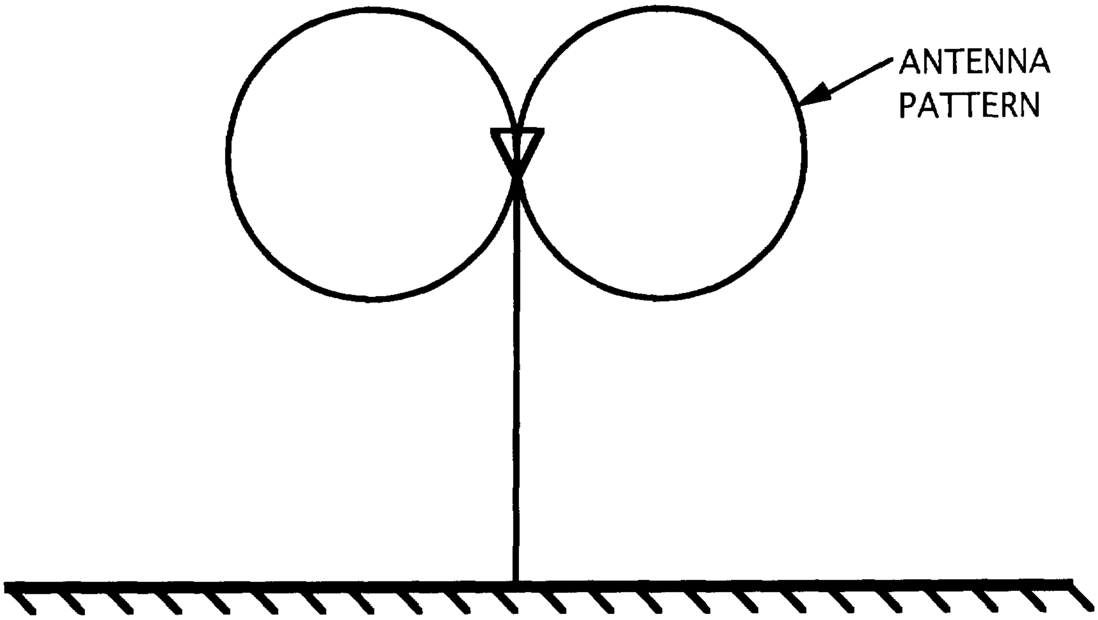

Figure A-1 Dipole pattern from a tower.

This is naturally accomplished because dipoles or folded dipoles are normally used as the radiating structure, and when vertically polarized, there is a null pointing downward. This null, though theoretically perfect, is typically 20 to 30 dB below the main beam maximum. Many of the antennas are mounted where the tower or building structure further blocks radiation that would normally reach the earth. However, we will take the conservative position that no further attenuation of the signal takes place in the downward direction and the null is 20 dB down.

Further, the maximum power transmitter used by the land mobile industry is 300 watts which further limits the power radiated downward. Under these constraints, the power radiated downward is 2.15 - 20 = -18.85 dB below the power input to the antenna. Table A-1 gives this Effective Radiated Power with respect to an isotropic point source (ERPi) straight down as a function of the operating power into the dipole.

TABLE A-1 Main Beam Power vs. Power Straight Down

OPERATING POWER, WATTS	ERPi DOWNWARD, WATTS
20	0.26
50	0.65
100	1.30
200	2.61
300	3.91

When R is the distance from the antenna to the point of observation, the power density in the free space far field of a radiator can be found from the equation:

$$p = \frac{ERPi}{4 \pi R^2}$$

The power density required by ANSI/IEEE C95.1-1993 for the uncontrolled environment in the 100-300 MHz range is 0.2 mW/Sq. cm. So, this equation can be solved for the range at which 0.2 mW/sq. cm is reached. For the highest input power, 300 Watts, this distance is 39.4 cm, and as the power decreases the distance decreases as is shown in Table A-2

Table A-2 required Separation vs. Operating Power

OPERATING POWER, WATTS	COMPUTED VERTICAL SPACING, cm
20	10.2
50	16.1
100	22.7
200	32.2
300	39.4

Near the midpoint of the land mobile band, 160 MHz, the length of a half wavelength dipole is 94 cm, and half of the antenna will extend 47 cm below the feed point. When the required separation is taken from the feed point of the antenna, the computed separations are ALL physically within the dipole arm.

Another approach is to use the well known technique of applying half of the power of each end of the half wavelength dipole (slightly unbalanced to yield the 20 dB null in the far field) to make the computation in the near field. This approach, when the average is taken over the vertical cross section of the human body as required by the ANSI standard, yields spacings for the power levels considered above that are all less than 20 cm from the end of the dipole.

But a human in the field at such close spacings intercepts energy from more angles than just straight down. And the average over the vertical cross section is probably not applicable when the energy is impinging on the subject from the head down. We could continue to make more complicated models, but under the conditions presented here, where the point of interest is directly beneath the antenna and at such close spacings, the only valid computation involves the SAR in the standard. That is beyond the scope of this Appendix, and will not be attempted here.

CONCLUSION

In conclusion, however, it has been shown that the spacing straight down, required from a half wavelength dipole used in the land mobile service at high band, is very small, and probably within 20 cm of the end of the dipole over the range of powers available to the land mobile industry.

Generalizing this to the controlled environment, where the levels of the MPE in the ANSI/IEEE standard are even higher, the spacings will be even smaller. Thus, the elevated distances required to meet the ANSI/IEEE standard at high band in the land mobile industry are much smaller than computed in the NPRM.

APPENDIX B

SUMMARY

For antennas radiating 300 Watts of power in use in the land mobile service at high band, the separation required by ANSI/IEEE C95.1-1992 is within the near field of antennas with gain in excess of 3 dBd. Only in the case of the 0 dBd dipole and the 3 dBd antennas does the separation required fall within the far field. The computed minimum horizontal spacing that results to maintain the power density at or below the required 0.2 mW/sq. cm of the ANSI/IEEE uncontrolled environment is 4.33, 6.04, 4.11, and 1.73 meters respectively for 0, 3, 5.8, and 9 dB antennas. The corresponding spacing for the controlled environment are 1.98, 1.98, 0.82, and 0.36 meters.

INTRODUCTION

In this Appendix, the separation required by the ANSI/IEEE standard from omnidirectional base station antennas operating at high band (150 - 174 MHz) in the land mobile service will be investigated. The worst case separation occurs on the main beam of the antenna. The range of antenna gains in use will be presented, and the highest power available, 300 Watts, will be used in the analysis to quantify the worst case separation for each antenna.

The high band frequencies used in this analysis were chosen because the levels required by the MPE of the standard are lower than at any other frequency. This maintains the worst case nature of the analysis consistent with the high power and main beam location.

In this Appendix, it will be assumed that the antennas are in a relatively free space environment so that there are no important reflections present. In Appendix D, to follow, the presence of a reflector nearby and within the main beam of the antenna will be investigated.

ANALYSIS

Over the frequencies included in high band, the Maximum Permitted Exposure permitted by ANSI/IEEE C95.1-1992 is 0.2 mW/cm^2 in the uncontrolled environment. This level is an average to be determined over the vertical cross section of the human body and over any 30 minute period. In this analysis, we will determine the distance from the antenna that will assure that an individual will meet this standard.

The maximum power available to the land mobile service is 300 watts out of the transmitter. There are losses in the feed lines that transport this energy to the antenna; however to be conservative, that attenuation will not be included in this analysis. Therefore, a worst case power of 300 Watts of power into the antenna will be used throughout this Appendix. Further, the duty cycle will be 100 % over the 30 minute period. This almost never happens, but will be another worst case assumption.

Far Field Analysis

The omnidirectional antennas used in this band include the simple dipole as well as collinear arrays of dipoles or folded dipoles. The full range of gains is encompassed by the antennas included in Table B-1. These are Celwave antennas, and their characteristics are published in Product Selection Guide No. 191. Also included in Table B-1 is D, the computed distance to the far field, which is calculated from equation (1) for 162 MHz; λ is the wavelength and L is the length of the antenna.

TABLE B-1 Antennas Used in This Analysis

ANTENNA MODEL	ANTENNA TYPE	GAIN, dBd	LENGTH METERS	FAR FIELD, METERS
BA1012	dipole	0	.93	0.93
PD1167	dipole array	3	2.4	6.22
PD200	dipole array	5.8	5.8	36.33
PD654	folded dipole array	9	13.4	193.92

$$D = \frac{2\,L^2}{\lambda} \qquad (1)$$

The maximum Power density, p, produced in the far field of an antenna is given by the expression:

$$p = \frac{Po\ Go}{4\,\pi\,R^2} \qquad (2)$$

Here, Po is the power into the antenna, Go is the absolute gain over an isotropic point source, and R is the distance to the point of observation. The power density produced just at the limit to the far field as shown above in Table B-1 can be determined from this expression, and with 300 watts of power into the antenna, that result is shown in Table B-2.

TABLE B-2 Computed Power Density at the Far Field Distance

ANTENNA TYPE	FAR FIELD, METERS	POWER DENSITY, mW/cm^2
BA1012	.93	4.53
PD1167	6.2	0.203
PD200	36.3	0.0113
PD654	193.9	0.0008

Since the power density required by ANSI/IEEE is 0.2 mW/cm^2, it is evident that the only antennas for which the far field can be used to make the computation is the BA1012, a simple dipole and the PD 1167 a collinear array. The other two gain antennas require a near field analysis to be correct. So, we will complete the analysis for the two smaller antennas and then proceed to the other gain antennas.

Short Antenna Analysis

In the Rationale section of ANSI/IEEE C95.1-1992, Paragraph 6.6 Measurement Procedures, it states:

> "For Practical measures of compliance with the standard, the average of a series of ten field strength measurements performed in a vertical line with uniform spacing starting at ground level up to a height of 2 m shall be deemed sufficient."

This procedure will be used to determine the spacing at which compliance with the standard is met with 300 Watts into the dipole. The relative field radiated from the main beam of an antenna is well approximated by:

$$E = \cos^{a}(\varnothing)$$

For the dipole a = 1.3 and for the PD1167 a= 7.0. This equation can be squared to obtain the power pattern, and when we include this in equation (2), the power density in any direction is found by:

$$p = \frac{Go\ Po\ \cos^{2a}(\varnothing)}{4 \pi R^2} \qquad (3)$$

This equation has been solved so that the 10 point average described in the ANSI standard was produced. The spacing directly on the main beam of the half wavelength dipole at which that average is 0.2 mW/cm^2 is 4.33 meters and for the PD 1167 it is 6.04 meters.

Near Field Analysis

One method used to determine the power density in the near field of a collinear array is to draw a cylinder of length L around the antenna and assume that all of the power is spread uniformly over the surface of the cylinder. This technique, though not completely rigorous, does provide spacings that are very close to the spacing determined through more rigorous computations. When the computation is rigorously made, there are maximum and minimum values produced by the vector sum of the fields at any point a fixed distance from the radiator. But, the process of taking the average, as required by the ANSI/IEEE standard reduces these peaks to the approximate value obtained using the cylindrical model.

The power density using the cylindrical model is the power radiated divided by the area of the cylinder. A major difference between this computation of power density and that for the far field in equation (2) is that the gain of the antenna is omitted. This is because the "gain" is provided by constraining the energy to the surface of the cylinder. One way to view this is as the radius, R, increases, the angular beamwidth gets smaller and smaller, and hence the gain of the antenna gets larger and larger. The equation for the power density is therefore:

$$p = \frac{Po}{2 \pi R L} \qquad (4)$$

The equivalent power density required to meet the ANSI/IEEE standard (0.2 mW/sq. cm) can be substituted into equation (4) and then it can be solved for the Radius R at which the standard is met. All of the antennas are longer than the 2 meter length of the human assumed in the ANSI/IEEE standard, and we will assume that the individual is wholly within the aperture of the antenna so whole body exposure results. The resulting computed spacings are 4.11 meters for the PD200 and 1.73 meters for the PD654.

CONCLUSION

The resulting spacing required in the ANSI/IEEE uncontrolled environment for 300 watts input to the omnidirectional antennas available at high band to the land mobile service is given in Table B-3. These spacings are computed for the worst case of an individual located in the main beam of these antennas and it is assumed that the transmitters are on continuously.

TABLE B-3 Computed Spacing With 300 Watts Input
That is Needed to Meet The ANSI/IEEE Standard
in the Uncontrolled Environment

ANTENNA TYPE	GAIN, dBd	SPACING, METERS
BA1012	0	4.33
PD1167	3	6.04
PD200	5.8	4.11
PD654	9	1.73

Generalizing to the controlled environment where the ANSI/IEEE MPE requirement for equivalent power density is 1.0 mW/sq. cm, five times greater, this nominal spacing will be reduced even further. The resulting spacings for the controlled environment are:

TABLE B-4 Computed Spacing With 300 Watts Input
That is Needed to Meet The ANSI/IEEE Standard
in the Controlled Environment

ANTENNA TYPE	GAIN, dBd	SPACING, METERS
BA1012	0	1.98
PD1167	3	1.98
PD200	5.8	0.82
PD654	9	0.36

APPENDIX C

SUMMARY
Computations of the power density produced by paging base stations radiating 3,500 Watts ERP in the 900 MHz band have been made. Omnidirectional antennas produce fields that are within the ANSI/IEEE standard for a controlled environment at spacings that are less than 0.5 meters from the antennas. Directional antennas produce the same result at spacings that are less than 4 meters on the main beam and much less when off of the main beam.

INTRODUCTION
The maximum ERP permitted the land mobile industry is 3,500 Watts for paging stations in the frequency range 928-944 MHz. In addition, the new PCS authorization also allows this power level. In this Appendix, the spacing necessary to maintain the level of exposure to electromagnetic energy within the 1992 ANSI/IEEE standard for these high power levels will be computed.

ANALYSIS
It is not economical to obtain the 3,500 Watts ERP by radiating that much RF from a simple dipole, so gain antennas are used. It is assumed that the maximum power base station that will be available is 500 Watts, so the gain of the antenna must make up the difference. Table C-1 lists several antennas taken from the Celwave Product Selection Guide number 191 that might be used to radiate 3,500 Watts ERP under this limitation.

TABLE C-1 Antennas Used to Radiate 3,500 Watts ERP

				BEAMWIDTH, deg.	
ANTENNA	TYPE	HEIGHT, m	GAIN, dBd	VERTICAL	HORIZONTAL
PBR12	Omni	6.10	12	5.3	N.A.
PBR10	Omni	3.96	10	3.5	N.A.
PD1110	Omni	3.35	9	6.0	N.A.
PD10108	Yagi	0.16	10	42	50
PD10108D	Yagi	0.16	13	42	22
PD1132R	Reflector	2.67	16	8	60

The power into each of the antennas that is necessary to produce 3,500 Watts ERP is a function of the antenna gain. As used by the FCC, the ERP is the product of the power into the antenna and the absolute power gain with respect to a half wavelength dipole. The power required by each antenna to produce 3,500 Watts is shown in Table C-2.

TABLE C-2 Power Into the Antennas Required to Produce 3,500 W ERP

ANTENNA	TYPE	POWER, W
PBR12	Omni	220
PBR10	Omni	350
PD1110	Omni	440
PD10108	Yagi	350
PD10108D	Yagi	175
PD1132R	Reflector	90

The Yagi antennas in this list do not presently have a power rating that will allow them to accept the power required. However, they are included because it is possible to modify them to accept the power and they represent a class of antennas for this application that may be important in the future.

In the 900 MHz band, the Maximum Permitted Exposure (MPE) of ANSI/IEEE C95.1-1992 in controlled environments is given by:

$$MPE = \frac{f}{300}$$

At the worst case frequency, 928 MHz at the low end of the paging band, this is 3.09 mW/sq. cm. Now we can determine the spacing from these antennas that is required to maintain the power density below this level. We will assume further that the transmitter is continuously transmitting which is another worst case assumption. As a final worst case assumption, we will make the computation with the individual fully illuminated by the energy radiating from the antenna as opposed to the more usual case of partial illumination.

The cylindrical model described in Appendix B is used for the near field analysis of the Omni antennas. The analysis of the reflector antenna will use the same model, but the energy will be constrained to be within the horizontal half power beam width of 60 degrees. Of course, some energy flows outside these limits; however, that decreases the energy within the 60 degree sector. Thus, this is a worst case assumption. The analysis of the Yagi antennas is made using the technique described in the section Short Antenna Analysis in Appendix B. The results obtained for all of the antennas are shown in Table C-3.

TABLE C-3 Computed Spacing Necessary To Meet The ANSI/IEEE Standard MPE With 928 MHz 3,500 Watt ERP Paging Stations

ANTENNA	SPACING, m
PBR12	0.186
PBR10	0.457
PD1110	0.676
PD10108	3.58
PD10108D	3.58
PD1132R	1.05

The long antennas serve to spread the energy out over several wavelengths, so that there is no concentration in any one small area. The Yagi antennas, however, produce a fairly concentrated area of energy, and that is why the field takes almost 4 meters to get down to the level of the ANSI/IEEE MPE. In every case, the computation has been made in the direction of the main beam, and in all other directions the spacing is reduced from that computed. So, this represents a worst case analysis for this situation.

CONCLUSION

A worst case analysis has been made of the spacings from high ERP gain antennas that can assure that individuals in the near proximity will meet the ANSI/IEEE C95.1-1992 standard for exposure of people to RF. The worst case assumptions included continuous operation for periods in excess of 6 minutes and individuals stationary within the fields over that period. With an ERP of 3,500 Watts, the highest spacing results from an antenna with horizontal and vertical directivity, but it is less than 4 meters even when the exposed individual is directly in the main beam of the antenna. It is less in all other directions. For long aperture antennas, the spacing is approximately one meter or less.

APPENDIX D

SUMMARY

An individual in the presence of an EM source of 300 Watts at 160 MHz with reflectors present is typically exposed to fields below the ANSI standard for uncontrolled environments when they are more than a few meters from the antenna. This results because the installation places the main beam above the individual. The distance is small with respect to the size of buildings, so any individual on another building will not be exposed to fields in excess of the ANSI standard.

INTRODUCTION

In Appendix B, the fields produced near land mobiles antennas radiating 300 Watts at high band were computed on a theoretical basis. The antennas were located in areas where there were no major large metallic surfaces nearby to produce reflections. In a pragmatic world there are large reflecting surfaces nearby that will modify the result that was obtained. In addition, the antennas are typically located where the general population is not located in the main beam of the antenna. In this Appendix, we will include the effect of these real world conditions.

In ANSI/IEEE Standard C95.3-1991, Appendix B gives an equation for computing the "distance to the boundary of the potentially hazardous zone (in the presence of reflections) as follows.":

$$r = \sqrt{G P / \pi W}$$

where G is the gain of the antenna, P is the power delivered to the antenna, and W is the power density that is required. This equation is derived from the far field power density from a radiator with perfect reflection from a large planar reflector far from the point of interest reflecting directly back to the point of exposure. It reliably yields distances which keep people from fields that exceed the standard. But it is often conservative, especially when the point of consideration is in the near field of the radiator or near the reflector. It does not accurately describe the spacing of interest but errs on the safe side.

In the present case, we are potentially in the near field of the antenna and the individual is not suspended in free space in front of a reflector. They are located on a ground plane (perhaps a rooftop) and there is another ground plane perpendicular to the first in the near proximity (perhaps a penthouse wall).

ANALYSIS

Figure D-1 shows pictorially the situation which is of interest. We have an individual walking on a rooftop in the presence of an antenna, and the antenna is mounted at some elevation above the rooftop. Typically this is the height of a single floor of a building, 9 to 15 feet. In Appendix B we showed that the 3 dB antenna had the largest required spacing in free space, so it will be used in this computation. Two half wavelength radiators spaced one wavelength apart yield the required gain.

There is a penthouse or other wall nearby which reflects energy in the horizontal plane. There will be a reflection of the energy from the antenna off of the rooftop back up into space above the roof. We will assume the worst case, that the wall and rooftop are perfect reflectors. The radiated Electric and Magnetic fields are reflected from the wall as well as the rooftop and add vectorally to produce the resultant fields. In order to compare the result to the requirements of the ANSI standard, the 10 point average will be computed in the vertical plane as described in Appendix B.

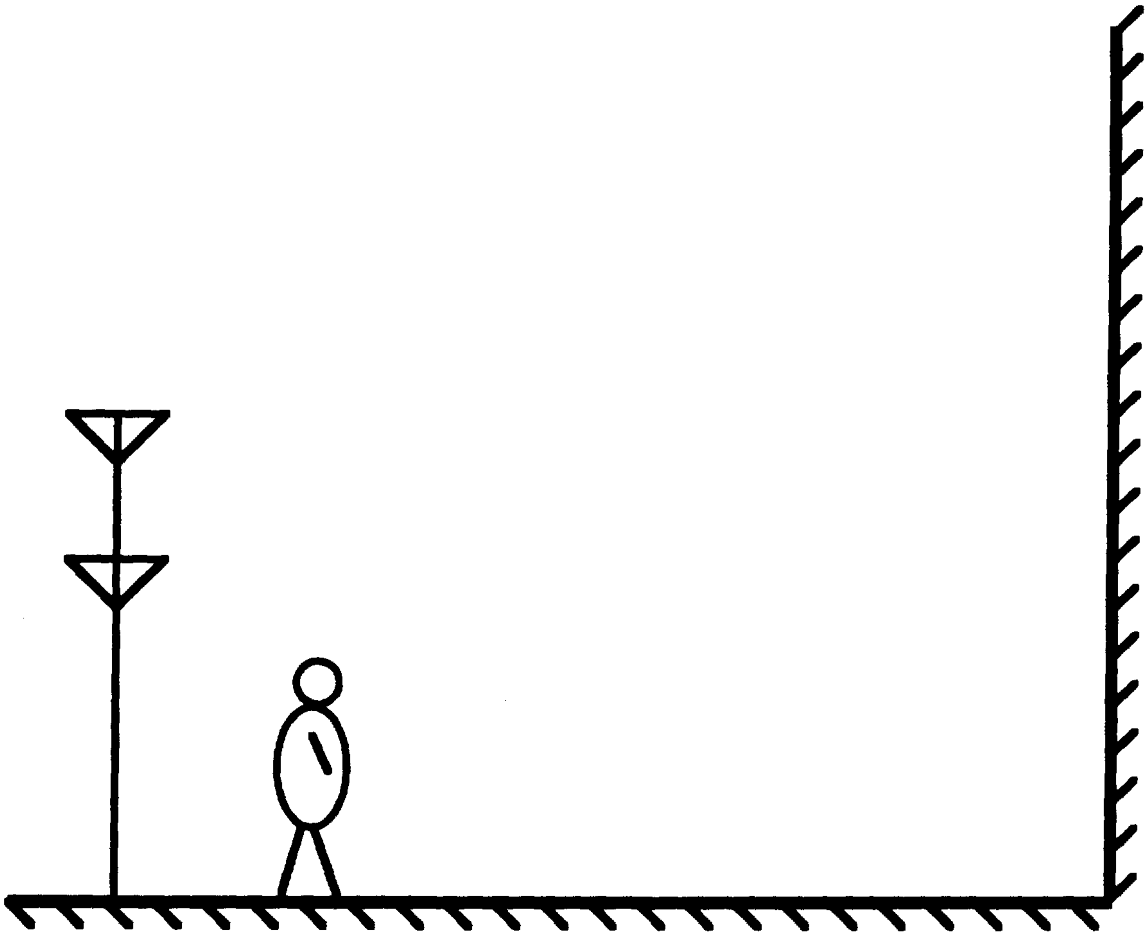

Figure D-1 Pictorial representation of the computation of interest.

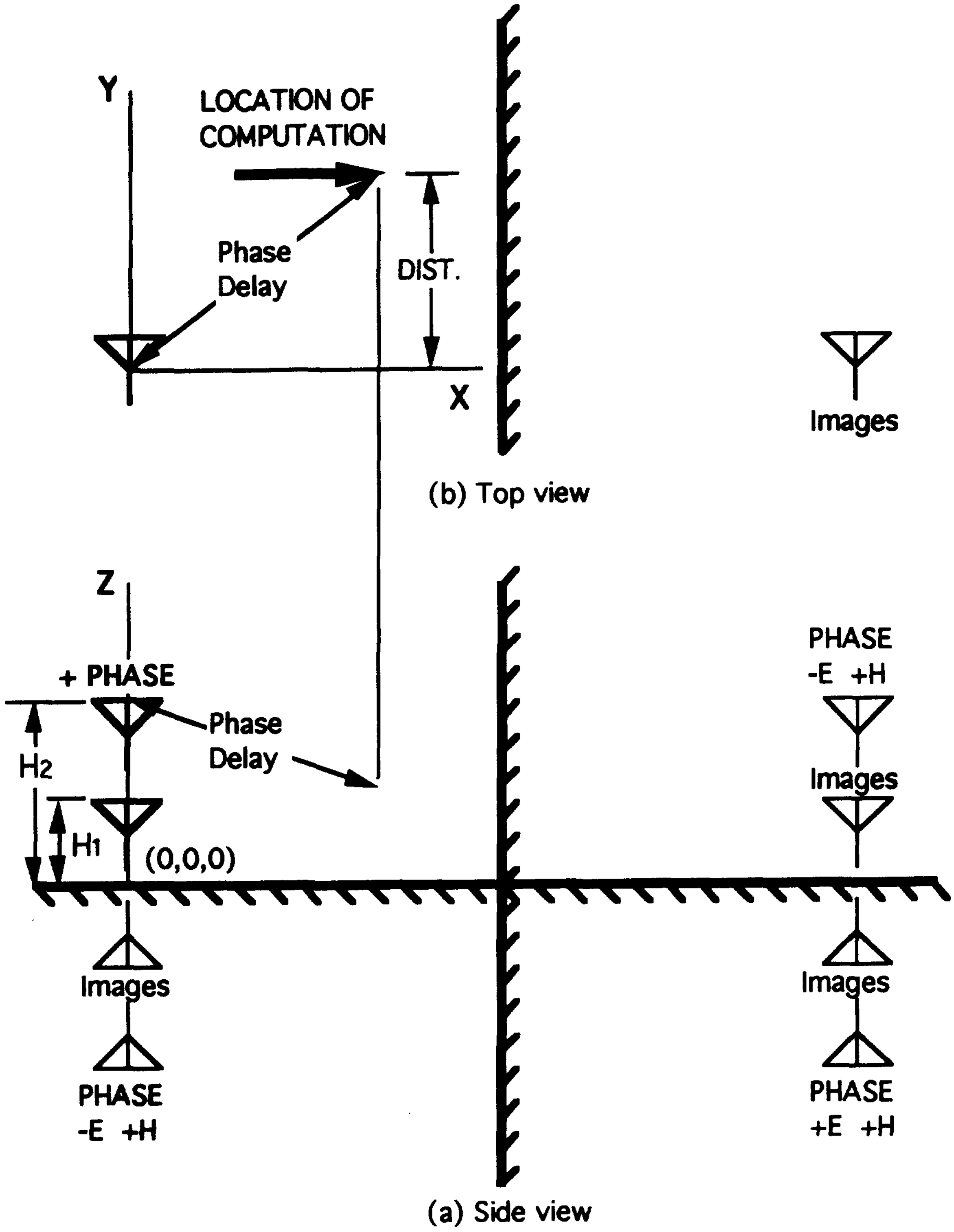

Figure D-2 Geometry used for he computation: (a) Side view of the antenna and images, (b) Top view of the antenna and images.

The geometry for the computation is shown in Figure D-2. Image theory is used to reflect the radiators into the opposite side of the ground plane. The computation will be made in the far field of the radiators but in the near field of the total array, so the far field pattern of each dipole will be used to determine the magnitude of the radiation in each direction. This is well approximated for the Electric field, E and the Magnetic field, H by:

$$E(\emptyset) = \cos(\emptyset)^{1.5} \qquad H(\emptyset) = \cos(\emptyset)^{1.5}/377$$

The fields are attenuated by free space attenuation as they leave the radiators and images, and there is a delay phase shift for each. The resulting field is the vector sum from each of the radiators and images for E then H with the appropriate image phases.

At the center of High Band, 162 MHz, computations have been made to determine the spacing required for both E and H. The wall was located at 4, 5, and 6 meters from the antenna, and the X and Y coordinates were varied over a range necessary to encompass the required field strengths. Figures D-3 and D-4 show the results for a wall 5 meters away and the height of the lower radiator of about 9 feet or 2 1/4 wavelengths.

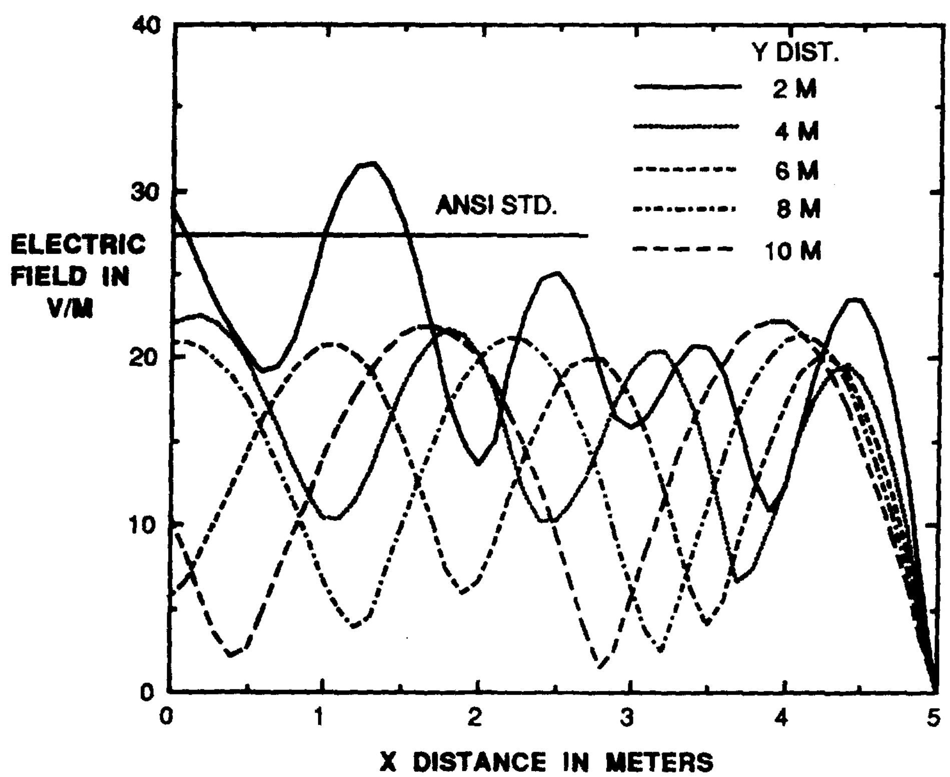

Figure D-3 2 Meter vertical average of the Electric field near a 3 dBd antenna with 300 Watts near a wall that is 5 Meters from the antenna at 162 MHz.

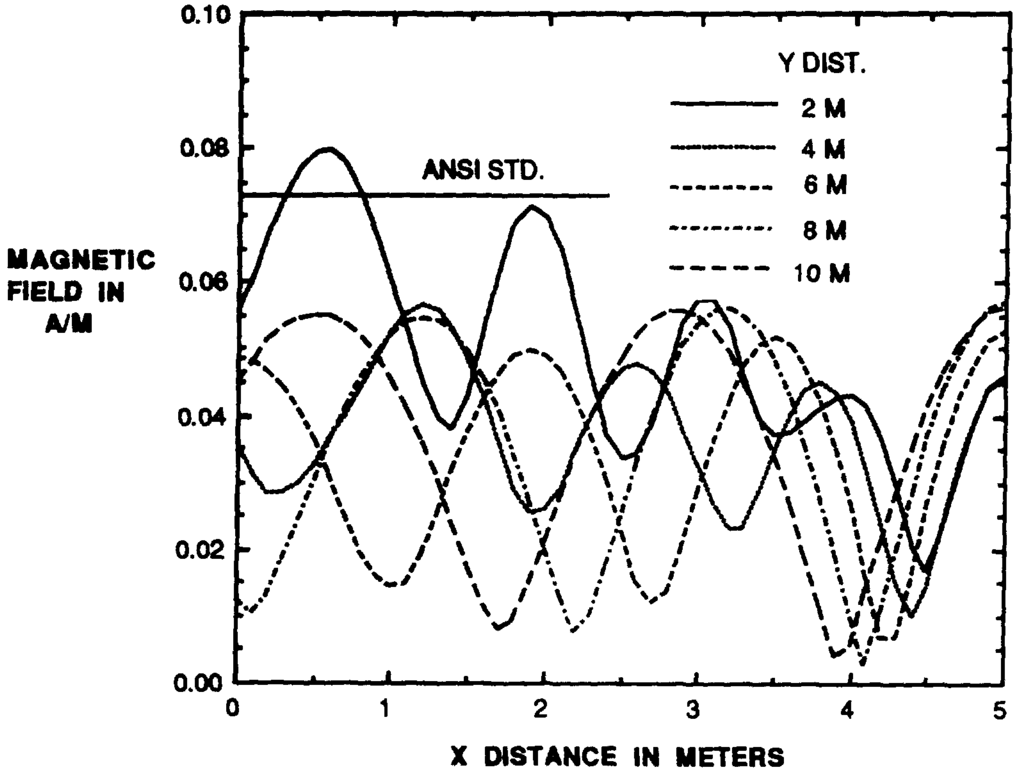

Figure D-4 2 Meter vertical average of the Magnetic field near a 3 dBd antenna with 300 Watts near a wall that is 5 Meters from the antenna at 162 MHz.

The MPE of ANSI C95.1-1992 is shown, and it is evident that the fields shown at locations at and beyond Y = 4 meters are all below the standard for both E and H. The same is true when the wall is located at X = 4 and X = 6 meters. The parameter of importance is the radial distance from the axis of the antenna to the location of the computation. This distance is the square root of the sum of the squares of X and Y. For all of these cases , the fields meet the MPE when this radial distance from the antenna is greater than 3 meters.

This is about one-half of the spacing of 6 meters required in the case computed in Appendix B where the antenna was in free space and the fields were computed on the main beam. The Appendix B analysis represented a "worst-case" theoretical installation. The analysis in this Appendix reflects a practical installation, and is presented here to provide a general indication of the effect of reflections.

If the antenna were to be lower, the computed required spacing to meet the ANSI limits would, of course, be somewhat larger. However, it should be noted that it is undesirable to mount an antenna at a height lower than used in this analysis, because the practical effect of the finite sized finite conductivity rooftop beneath the antenna is to elevate the main beam. This reduces the signal directed toward the earth, and a major portion of the desired coverage area would be adversely affected.